

# **November 1996**

## **Preliminary Data Summary**

by      Field Research Facility

U.S. Army Corps of Engineers  
Waterways Experiment Station  
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# Preface

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This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

**Data from these reports are now available via the World Wide Web at  
<http://www.frf.usace.army.mil>**

These web pages contain general information about the Field Research Facility and data from 1980 to the present.

Please note the new web address, <http://www.frf.usace.army.mil>

Your comments and criticisms are welcome.

# Introduction

## 1

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The U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory's (CHL) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511 ([c.baron@cerc.wes.army.mil](mailto:c.baron@cerc.wes.army.mil)).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

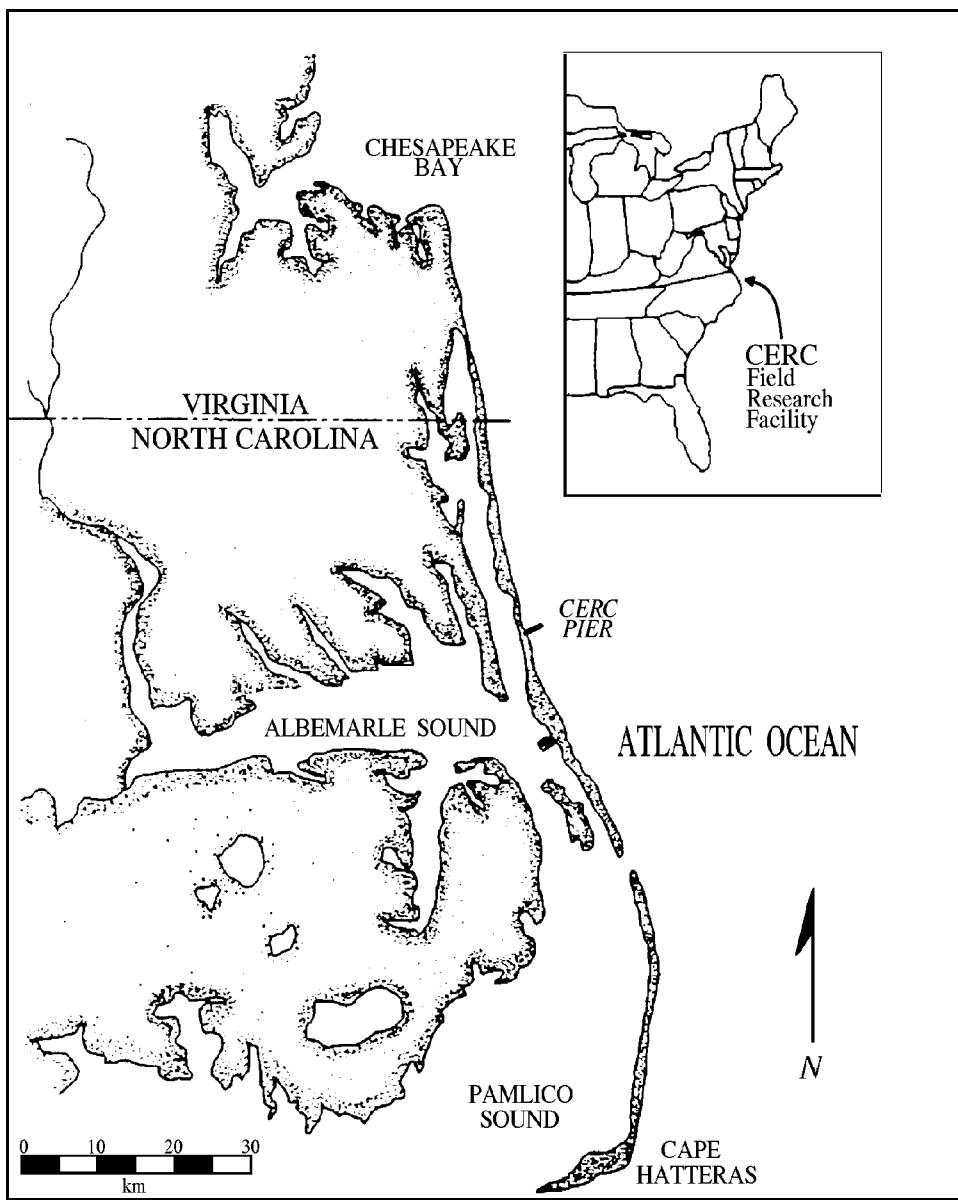


Figure 1. FRF Location Map

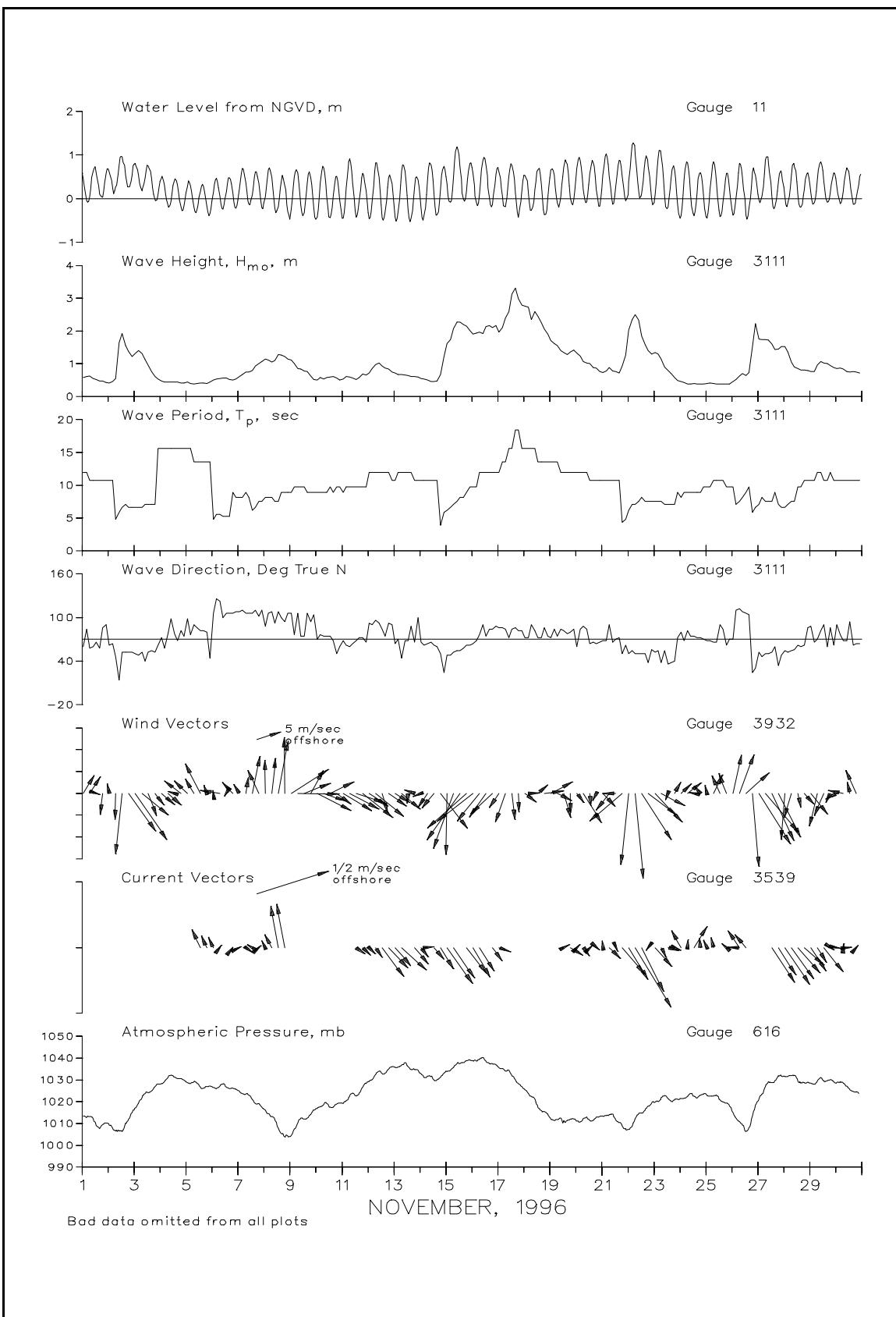


Figure 2. Month at a Glance

**Table 1**  
**Instrument Status/Data Availability**

		November 1996																														
		Day of the month																														
Gauge ID	Description/Remarks	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
3932	Anemometer	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
641	Pressure Gauge on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
625	Baylor staff on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
111	Pressure Gauge center of 8 Meter Array	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
630	Waverider buoy 4.0 km offshore	Gauge Status	-	-	-	-	-	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	-	-	-	-	-	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
3539	Current meter 343 m north of FRF pier (1.6 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	-	-	-	-	/	*	*	-	/	*	/	*	/	*	/	*	*	*	*	*	*	*	*	*	*	/	*	*		
11	NOAA tide gauge at end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Visual Observations (daily oceanographic and meteorological observations)		Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Gauge Status		* = Operational	/	= Partial	-	= Non-Operational																										
Data Collected		* = All	/	= Partial	-	= None																										
Visual Observations		* = Complete	/	= Partial	-	= None																										

**Table 2**  
**Gauge Locations**

Gauge*	Description	* Latitude	* Longitude	* FRF Coordinates	* Gauge Depth	* Water Depth
ID *		* Degrees N	* Degrees W	* CrossshoreT Longshore*	NGVD, m	* NGVD, m
616	* Atmospheric Pressure*	36 10' 57.03"	* 75 45' 5.50"	* 11.60	* 569.00	* -----
3932	* Anemometer	* 36 11' 1.23"	* 75 44' 43.07"	* 585.20	* 517.30	* 19.50
641	* Pressure Gauge	* 36 10' 57.71"	* 75 44' 56.23"	* 239.11	* 516.64	* -1.64
625	* Baylor Staff	* 36 11' 1.04"	* 75 44' 43.72"	* 568.00	* 516.64	* Surface
3111	* 8 Meter Array North	* 36 11' 19.14"	* 75 44' 36.41"	* 915.23	* 990.16	* -7.50
	* 8 Meter Array South	* 36 11' 11.28"	* 75 44' 33.28"	* 914.20	* 735.37	* -7.42
	* 8 Meter Array East	* 36 11' 13.70"	* 75 44' 32.56"	* 954.51	* 800.58	* -7.62
	* 8 Meter Array West	* 36 11' 12.48"	* 75 44' 37.11"	* 834.66	* 800.37	* -6.98
111	* Pressure Gauge in center of 8 M Array	* 36 11' 14.06"	* 75 44' 34.39"	* 914.43	* 825.52	* -7.76
630	* Waverider Buoy	* 36 10' 5.10"	* 75 41' 59.30"	* 3934.96	* -2400.81	* Surface
3539	* Current Meter	* 36 11' 23.57"	* 75 44' 9.12"	* 1605.80	* 907.60	* -11.60
11	* NOAA Tide Gauge	* 36 11' 1.25"	* 75 44' 42.60"	* 596.49	* 514.20	* Surface
R	R	R	R	R	R	R

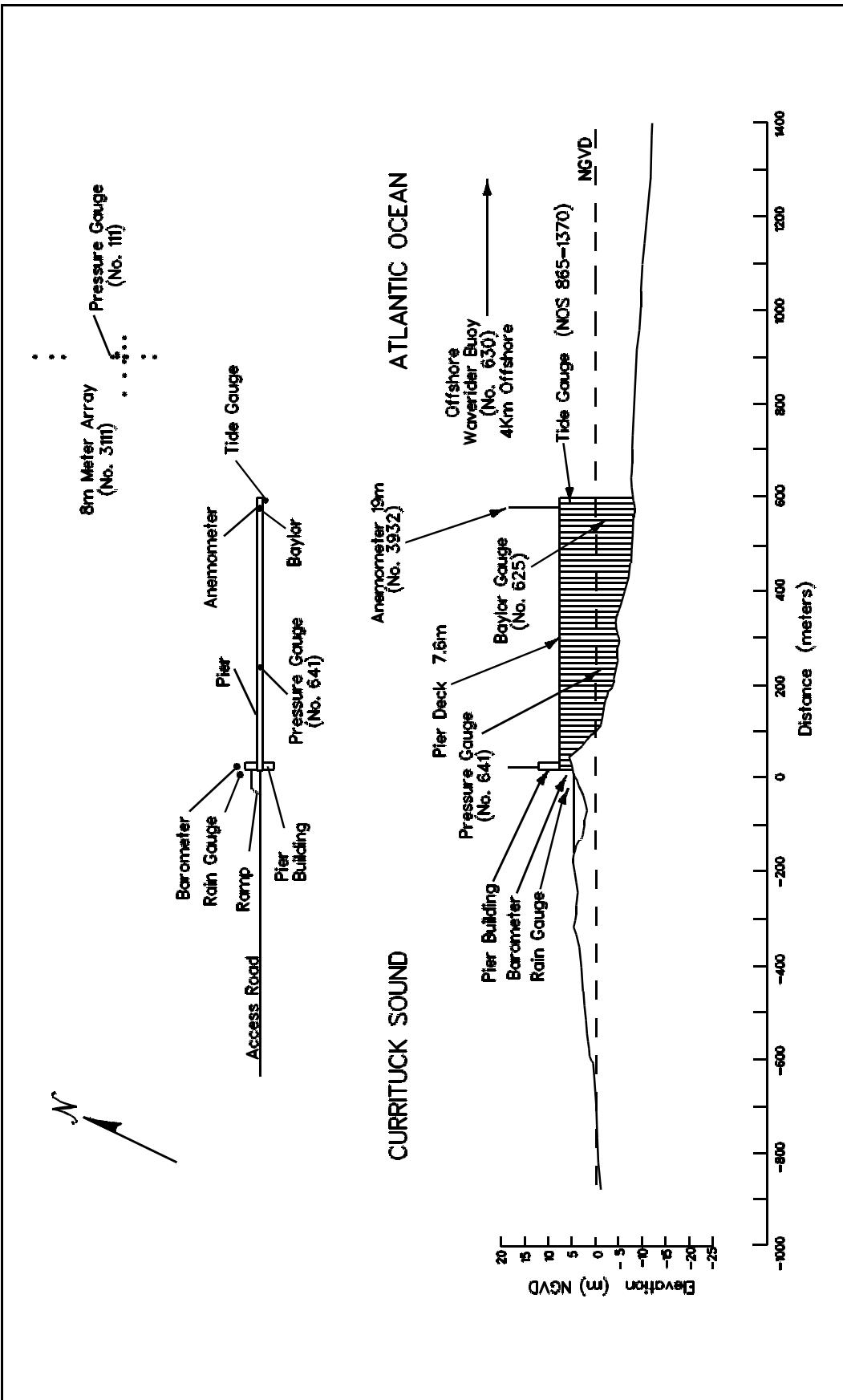


Figure 3. Instrument Locations, Elevations From NGVD

# Meteorological Data

## 2

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A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -  
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -  
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -  
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -  
 $m/s \times 1.943 = kn$

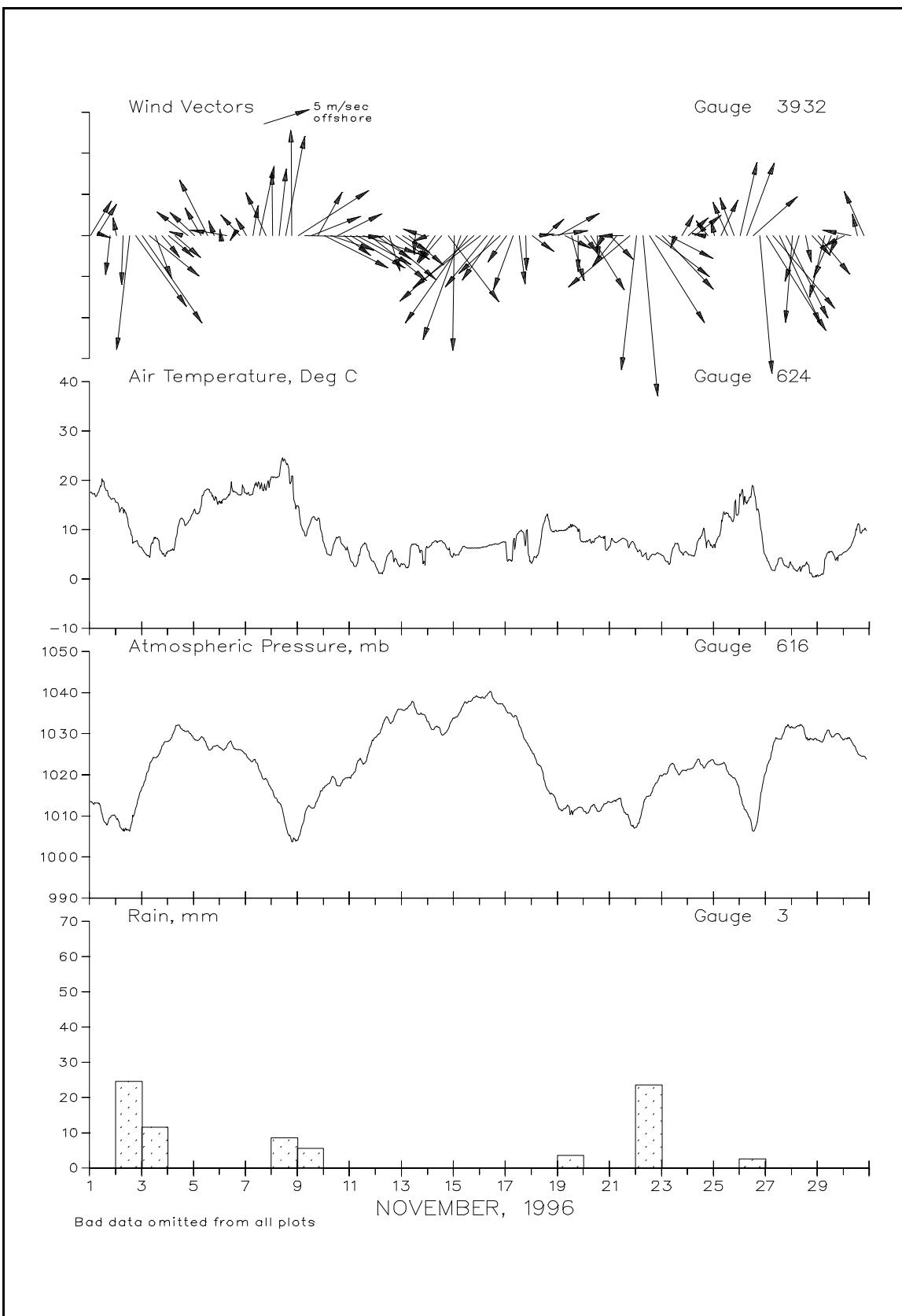


Figure 4. Meteorological Monthly Summary

**Table 3**  
**Meteorological Data**

Nov 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	5	207	17.5	1013.5	0
	700	4	208	17.0	1013.1	0
	1300	1	1	19.9	1009.0	0
	1900	5	5	16.6	1009.6	0
2	100	2	170	15.5	1009.3	0
	700	6	1	14.2	1006.5	25
	1300	14	5	10.2	1006.4	0
	1900	10	1	7.7	1012.0	0
3	100	12	329	6.0	1017.1	0
	700	7	313	4.5	1022.0	11
	1300	5	342	8.5	1024.2	0
	1900	3	325	5.4	1027.0	0
4	100	4	314	5.6	1028.2	0
	700	4	315	7.0	1031.1	0
	1300	1	109	12.3	1031.3	0
	1900	4	131	11.5	1030.7	0
5	100	4	137	14.2	1028.8	0
	700	4	153	14.9	1029.2	0
	1300	7	156	18.3	1026.8	0
	1900	2	162	15.9	1027.1	0
6	100	1	172	15.4	1026.6	0
	700	4	99	16.6	1027.1	0
	1300	1	28	17.7	1026.8	0
	1900	3	140	17.1	1026.2	0
7	100	2	152	17.3	1024.8	0
	700	4	188	17.7	1023.5	0
	1300	9	190	19.2	1021.0	0
	1900	6	158	18.0	1019.1	0
8	100	8	179	20.8	1016.2	0
	700	8	185	20.8	1013.3	9
	1300	12	189	23.7	1008.0	0
	1900	13	179	20.9	1003.8	0
9	100	9	233	14.8	1004.5	0
	700	8	271	8.9	1010.4	5
	1300	6	245	12.1	1012.0	0
	1900	6	205	12.4	1014.2	0
10	100	8	300	6.9	1017.0	0
	700	5	1	4.8	1018.8	0
	1300	5	240	8.3	1017.5	0
	1900	4	311	6.6	1018.9	0

**Table 3**  
**Meteorological Data (continued)**

Nov 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	7	305	3.8	1019.3	0
	700	7	301	2.8	1022.7	0
	1300	6	1	7.0	1022.7	0
	1900	8	312	4.5	1026.8	0
12	100	5	308	2.3	1029.3	0
	700	8	313	1.5	1032.5	0
	1300	4	345	5.3	1033.0	0
	1900	5	309	4.1	1034.9	0
13	100	3	306	2.8	1035.8	0
	700	5	314	2.7	1036.9	0
	1300	2	4	7.1	1036.1	0
	1900	2	111	5.8	1034.8	0
14	100	2	66	6.5	1032.9	0
	700	4	30	7.7	1031.7	0
	1300	4	35	7.8	1029.9	0
	1900	10	1	6.0	1031.2	0
15	100	14	1	5.0	1033.8	0
	700	13	17	5.8	1035.7	0
	1300	12	31	6.4	1037.5	0
	1900	11	44	6.2	1038.9	0
16	100	10	47	6.4	1038.7	0
	700	8	34	6.7	1039.5	0
	1300	6	30	7.1	1038.6	0
	1900	6	42	7.3	1037.4	0
17	100	4	30	5.0	1035.6	0
	700	7	17	7.6	1034.1	0
	1300	6	354	9.6	1032.1	0
	1900	4	359	7.6	1028.4	0
18	100	3	311	3.5	1025.5	0
	700	2	264	5.7	1022.4	0
	1300	3	224	12.6	1017.6	0
	1900	4	261	9.7	1015.4	0
19	100	5	238	9.7	1012.1	0
	700	3	300	9.8	1011.9	4
	1300	6	346	10.5	1011.4	0
	1900	4	359	9.6	1012.2	0
20	100	3	327	7.5	1011.1	0
	700	7	332	7.4	1012.3	0
	1300	3	357	8.4	1011.3	0
	1900	2	26	8.2	1012.9	0

**Table 3**  
**Meteorological Data (concluded)**

Nov 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	4	320	6.8	1013.4	0
	700	5	34	7.5	1014.1	0
	1300	3	88	8.2	1011.7	0
	1900	9	45	7.1	1008.9	0
22	100	16	5	6.1	1007.4	0
	700	20	1	4.7	1012.2	24
	1300	12	1	4.3	1014.9	0
	1900	7	311	5.0	1017.9	0
23	100	8	320	4.8	1019.8	0
	700	5	301	3.0	1021.8	0
	1300	2	18	7.3	1021.5	0
	1900	3	206	5.5	1020.9	0
24	100	3	224	4.9	1021.4	0
	700	4	228	4.9	1022.5	0
	1300	1	103	8.8	1022.5	0
	1900	2	144	7.7	1023.1	0
25	100	2	1	6.9	1022.9	0
	700	5	202	10.3	1022.7	0
	1300	4	159	13.4	1020.9	0
	1900	5	162	12.5	1019.3	0
26	100	9	191	16.8	1015.1	0
	700	9	197	15.2	1011.0	2
	1300	7	224	18.8	1006.3	0
	1900	17	355	11.8	1013.4	0
27	100	13	331	4.4	1021.1	0
	700	11	323	1.7	1027.0	0
	1300	12	338	4.3	1028.8	0
	1900	11	336	2.7	1031.9	0
28	100	11	4	2.6	1031.6	0
	700	6	14	2.2	1032.0	0
	1300	3	348	2.9	1029.5	0
	1900	3	321	0.8	1028.8	0
29	100	6	325	0.6	1028.5	0
	700	8	11	4.0	1029.5	0
	1300	5	19	5.5	1029.6	0
	1900	2	21	3.7	1030.1	0
30	100	3	58	5.4	1028.8	0
	700	3	102	6.6	1028.6	0
	1300	3	168	10.9	1025.5	0
	1900	6	1	10.0	1024.6	0
		Resultant		Mean	Mean	Total
		2	337	9.0	1022.6	80

# Wave Data

## 3

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Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using a iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height  $H_{mo}$  is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period  $T_p$  is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all  $H_{mo}$  and  $T_p$  values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 4**  
**Wave Data**

Nov 1996											
Day	Hour	641		625		3111			630		
		Pressure Gauge	Hmo,m Tp,sec	Baylor Gauge	Hmo,m Tp,sec	8 Meter Array	Hmo,m Tp,sec Dir,TN	Waverider	Hmo,m Tp,sec		
1	0100	0.37	9.9	0.50	10.7	0.57	12.0	60	inoperative		
	0700	0.34	11.7	0.54	11.2	0.62	10.8	58			
	1300	0.31	11.7	0.50	11.2	0.52	10.8	66			
	1900	0.28	11.2	0.57	10.7	0.47	10.8	86			
2	0100	0.29	10.3	0.46	10.7	0.42	10.8	62			
	0700	0.37	4.6	0.50	4.6	0.54	4.8	46			
	1300	1.32	6.5	1.67	6.3	1.92	6.6	52			
	1900	0.80	7.0	1.30	6.6	1.38	6.6	52			
3	0100	0.84	6.3	1.23	6.1	1.32	6.6	50			
	0700	0.86	6.6	1.32	6.5	1.32	6.6	52			
	1300	0.68	6.3	0.99	7.2	0.95	7.1	52			
	1900	0.40	5.9	0.68	7.0	0.60	7.1	52			
4	0100	0.31	16.0	0.49	6.5	0.47	15.7	72	inoperative		
	0700	0.24	16.0	0.43	15.1	0.44	15.7	78			
	1300	0.28	15.1	0.43	15.1	0.45	15.7	78			
	1900	0.25	16.0	0.45	15.1	0.41	15.7	82			
5	0100	0.37	15.1	0.54	15.1	0.45	15.7	98			
	0700	0.24	15.1	0.40	14.3	0.38	13.6	90			
	1300	0.33	12.2	0.47	14.3	0.41	13.6	82			
	1900	0.26	14.3	0.40	14.3	0.39	13.6	80			
6	0100	0.34	5.1	0.48	4.8	0.50	4.8	106			
	0700	0.40	5.4	0.54	5.7	0.54	5.6	122			
	1300	0.43	5.4	0.51	5.0	0.56	5.3	106			
	1900	0.38	6.0	0.47	8.3	0.51	8.9	106			
7	0100	0.50	8.1	0.55	8.1	0.62	8.2	108	inoperative		
	0700	0.61	8.3	0.69	8.1	0.74	8.9	106			
	1300	0.67	7.6	0.78	8.6	0.79	6.2	106	0.96	6.7	
	1900	0.86	7.4	0.89	7.8	1.01	7.6	102	1.26	7.2	
8	0100	1.00	7.8	1.09	7.6	1.15	8.2	88	1.48	7.7	
	0700	0.96	7.8	1.04	8.1	1.05	8.2	108	1.38	8.4	
	1300	1.04	8.1	1.16	7.2	1.28	7.6	108	1.66	8.4	
	1900	1.12	9.2	1.23	9.2	1.21	8.9	94	1.56	8.4	
9	0100	0.94	8.3	1.09	8.6	1.12	8.9	106	1.47	8.4	
	0700	0.79	9.9	0.82	9.9	0.85	9.8	106	1.10	10.1	
	1300	0.62	9.5	0.72	9.9	0.77	9.8	74	0.89	9.1	
	1900	0.64	8.9	0.63	8.9	0.63	8.9	94	0.82	8.4	
10	0100	0.33	9.2	0.56	9.2	0.49	8.9	70	0.79	9.1	
	0700	0.42	8.6	0.57	8.3	0.54	8.9	74	0.82	9.1	
	1300	0.34	9.2	0.52	9.2	0.59	9.8	74	0.66	9.1	
	1900	0.37	8.9	0.52	9.9	0.56	9.8	50	0.73	9.1	

**Table 4**  
**Wave Data (continued)**

Nov 1996													
Day	Hour	641 Pressure Gauge			625 Baylor Gauge			3111 8 Meter Array			630 Waverider		
		Hmo,m	Tp,sec		Hmo,m	Tp,sec		Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec	
11	0100	0.32	9.2		0.51	9.5		0.53	8.9	68	0.74	9.1	
	0700	0.40	9.9		0.62	9.9		0.59	9.8	60	0.82	10.1	
	1300	0.29	9.5		0.52	9.5		0.53	9.8	68	0.75	9.1	
	1900	0.42	8.6		0.68	9.9		0.68	9.8	72	0.91	3.9	
12	0100	0.41	4.7		0.67	12.9		0.72	12.0	92	0.95	10.6	
	0700	0.55	11.7		0.87	12.2		0.97	12.0	96	1.16	11.2	
	1300	0.57	12.2		0.88	12.2		0.93	12.0	84	1.03	11.8	
	1900	0.52	11.7		0.77	11.2		0.83	12.0	92	0.97	11.8	
13	0100	0.36	11.2		0.64	11.7		0.71	10.8	64	0.74	10.6	
	0700	0.44	11.7		0.66	12.2		0.67	12.0	44	0.80	11.8	
	1300	0.32	11.7		0.60	11.7		0.64	12.0	68	0.70	11.8	
	1900	0.34	11.7		0.57	11.2		0.61	10.8	66	0.65	11.2	
14	0100	0.30	11.2		0.57	11.2		0.55	10.8	66	0.61	11.8	
	0700	0.33	9.9		0.54	11.2		0.50	10.8	64	0.64	10.6	
	1300	0.30	10.7		0.49	10.7		0.45	10.8	62	0.61	11.2	
	1900	0.32	10.3		0.59	9.9		0.67	3.9	50	0.75	10.1	
15	0100	1.12	6.3		1.61	6.3		1.63	6.2	48	1.86	6.3	
	0700	1.30	7.0		2.01	7.0		2.08	7.1	52	2.21	6.7	
	1300	1.31	8.1		2.26	7.8		2.28	8.2	54	2.53	7.7	
	1900	1.05	8.1		2.11	9.2		2.15	8.9	62	2.38	9.1	
16	0100	1.08	10.3		1.91	10.3		1.91	9.8	64	2.22	9.1	
	0700	1.06	11.7		1.84	9.9		1.97	12.0	76	2.17	10.6	
	1300	1.44	12.2		1.81	12.9		2.13	12.0	74	2.19	12.6	
	1900	1.01	12.9		2.06	12.2		2.11	12.0	84	2.22	12.6	
17	0100	1.34	11.7		1.94	12.2		1.97	12.0	86	2.04	13.4	
	0700	1.21	14.3		2.23	14.3		2.40	13.6	84	2.20	11.2	
	1300	1.50	16.0		2.71	15.1		3.12	15.7	84	2.77	15.4	
	1900	1.10	18.3		2.92	17.1		2.99	18.5	82	2.69	16.7	
18	0100	1.62	16.0		2.44	17.1		2.76	15.7	72	2.46	16.7	
	0700	1.20	15.1		2.26	15.1		2.35	15.7	90	2.41	15.4	
	1300	1.36	14.3		2.33	14.3		2.45	13.6	72	2.27	14.3	
	1900	1.16	14.3		2.02	13.5		2.06	13.6	86	2.01	14.3	
19	0100	1.17	13.5		1.62	13.5		1.71	13.6	72	1.90	13.4	
	0700	0.95	13.5		1.32	13.5		1.55	13.6	74	1.38	11.8	
	1300	0.70	12.9		1.22	12.2		1.35	12.0	82	1.29	12.6	
	1900	0.76	12.2		1.30	12.2		1.37	12.0	80	1.28	12.6	
20	0100	0.78	12.2		1.25	12.2		1.33	12.0	60	1.24	11.8	
	0700	0.57	12.2		1.14	11.7		1.07	12.0	88	1.18	12.6	
	1300	0.55	11.7		0.92	11.2		1.01	10.8	64	0.99	10.1	
	1900	0.42	11.7		0.76	11.2		0.87	10.8	64	0.93	11.2	

**Table 4**  
**Wave Data (concluded)**

Nov 1996											
Day	Hour	641		625		3111			630		
		Pressure Gauge Hmo,m	Tp,sec	Baylor Gauge Hmo,m	Tp,sec	8 Meter Array Hmo,m	Tp,sec	Dir,TN	Waverider Hmo,m	Tp,sec	
21	0100	0.36	10.7	0.75	10.3	0.73	10.8	68	0.72	10.1	
	0700	0.51	4.9	0.87	5.1	0.89	10.8	90	0.98	5.1	
	1300	0.40	5.6	0.75	10.3	0.77	10.8	70	0.95	5.9	
	1900	0.59	4.3	1.00	4.1	0.92	4.4	50	1.18	4.1	
22	0100	1.24	6.0	1.74	5.9	2.03	6.2	50	2.34	5.9	
	0700	1.64	7.8	2.54	7.2	2.50	7.1	50	3.14	7.7	
	1300	1.31	7.2	1.83	7.8	1.84	8.2	50	2.31	7.7	
	1900	1.12	7.4	1.36	7.6	1.40	7.6	38	1.68	7.7	
23	0100	1.01	7.0	1.30	7.4	1.34	7.6	52	1.65	7.2	
	0700	1.00	7.6	1.14	7.0	1.14	7.6	38	1.46	7.2	
	1300	0.54	6.3	0.76	7.0	0.80	7.1	36	0.92	7.2	
	1900	0.44	6.8	0.55	7.0	0.58	7.1	40	0.68	6.7	
24	0100	0.17	5.5	0.43	8.9	0.45	8.2	80	0.56	9.1	
	0700	0.20	8.3	0.38	9.9	0.38	8.9	82	0.47	9.1	
	1300	0.13	8.9	0.37	9.5	0.40	8.9	74	0.40	8.4	
	1900	0.17	10.7	0.34	10.3	0.38	8.9	72	0.40	9.1	
25	0100	0.16	10.3	0.38	10.3	0.39	9.8	68	0.43	10.1	
	0700	0.21	10.7	0.38	10.7	0.39	10.8	66	0.42	10.6	
	1300	0.15	10.3	0.36	11.2	0.38	10.8	90	0.39	10.6	
	1900	0.18	9.9	0.35	10.3	0.38	9.8	62	0.42	10.6	
26	0100	0.22	4.5	0.47	10.3	0.45	9.8	70	0.60	9.1	
	0700	0.38	6.5	0.56	7.8	0.62	7.6	112	0.86	7.2	
	1300	0.33	8.9	0.64	8.9	0.65	8.9	106	0.87	8.4	
	1900	0.65	3.9	1.08	4.2	1.53	5.9	24	1.20	10.6	
27	0100	1.25	6.8	1.80	7.2	1.75	7.1	52	2.47	6.7	
	0700	1.40	7.4	1.65	6.1	1.74	7.6	50	2.29	7.7	
	1300	1.19	7.6	1.58	7.8	1.60	7.6	52	2.08	7.7	
	1900	1.15	6.6	1.27	6.8	1.44	7.1	34	1.82	7.7	
28	0100	1.16	7.0	1.50	6.6	1.53	6.6	54	1.87	7.7	
	0700	0.98	7.2	1.06	7.0	1.05	7.6	54	1.36	7.7	
	1300	0.68	6.0	0.77	10.3	0.85	9.8	62	0.95	7.2	
	1900	0.57	5.6	0.80	10.3	0.81	10.8	62	0.85	9.1	
29	0100	0.48	6.0	0.68	10.7	0.76	10.8	88	0.92	10.6	
	0700	0.65	10.7	0.94	11.2	0.96	12.0	70	1.03	11.2	
	1300	0.87	5.6	1.04	11.7	1.03	10.8	90	1.12	11.8	
	1900	0.69	5.6	0.92	11.2	0.95	12.0	86	1.01	10.6	
30	0100	0.67	5.9	0.83	10.7	0.85	10.8	90	0.92	11.2	
	0700	0.49	10.7	0.81	10.7	0.83	10.8	68	0.84	10.6	
	1300	0.45	10.7	0.75	11.2	0.75	10.8	94	0.87	10.1	
	1900	0.34	10.3	0.70	10.3	0.74	10.8	64	0.79	10.6	
Mean		0.67	9.5	1.00	9.9	1.05	10.0	72	1.29	9.8	
Std dev		0.39	3.2	0.60	2.8	0.64	2.8	19	0.67	2.5	

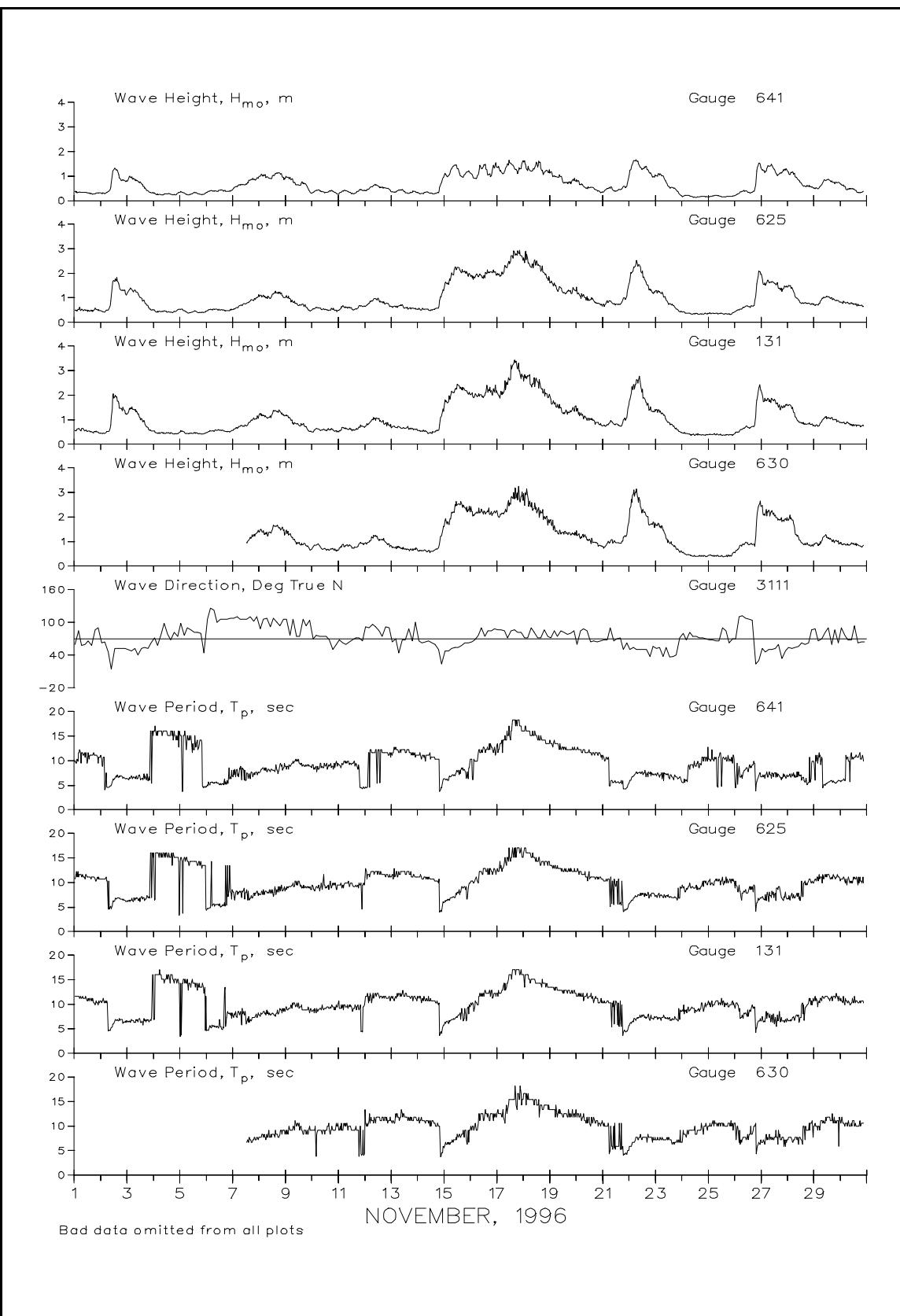


Figure 5. Wave Heights and Periods

# Current Data

## 4

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Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

**Table 5**  
**Current Meter Data - Gauge 3539**

NOVEMBER 1996																
		Cross Long					Cross Long					Cross Long				
Day	Time	Shore	Shore	Speed	Dir		Shore	Shore	Speed	Dir		Shore	Shore	Speed	Dir	
1	100					11	100				21	100	0	-4	5	
	700						700					700	-3	10	11	
1300		inoperative		1300	-3	6	7	129			1300	0	3	3	159	
1900				1900	-2	7	8	138			1900	-6	24	25	145	
2	100			12	100	-1	6	6	138	22	100	-2	27	27	153	
	700				700	-1	9	9	150		700	-6	51	51	153	
1300		1300		-5	26	26	147			1300	-1	36	36	157		
1900		1900		-5	19	20	141			1900	2	2	3	212		
3	100			13	100	-4	17	17	143	23	100	-4	17	18	143	
	700				700	-8	22	24	137		700	0	8	8	158	
1300		1300									1300	-5	5	8	110	
1900		1900		-3	15	16	144				1900	-2	3	5	117	
4	100			14	100	-1	8	9	146	24	100	1	-13	14	334	
	700				700	-3	1	4	84		700	-2	-4	6	5	
1300		1300		-2	11	11	144			1300	-12	-11	18	28		
1900		1900		-1	18	18	153			1900	-1	-6	7	355		
5	100			15	100	-5	31	32	149	25	100	0	-5	6	338	
	700				700	-4	26	27	149		700	0	-7	8	349	
1300	1	-13	14	338	1300					1300		inoperative				
1900	0	-9	10	338	1900	-5	23	24	146		1900	2	-3	4	315	
6	100	0	-7	8	338	16	100	-2	25	25	153	26	100	3	-1	
	700	-1	0	2	34		700	-2	20	20	152		700	3	-14	
1300		inoperative		1300								1300	3	-11	12	
1900	0	0	0		1900	-1	12	12	148			1900				
7	100	0	0	0		17	100	-5	6	8	115	27	100	inoperative		
	700	-2	5	6	129		700						700			
1300	2	-2	4	306	1300							1300	-4	30	30	151
1900	-1	0	2	43	1900							1900	-3	23	24	151
8	100	0	-5	6	338	18	100					28	100	-5	32	33
	700	1	-10	11	335		700		inoperative				700	-5	28	28
1300	-5	-30	32	351	1300							1300	-6	23	24	143
1900	-5	-32	33	351	1900							1900	-6	17	18	136
9	100				19	100						29	100	-2	20	21
	700					700							700	-1	12	13
1300		inoperative		1300	-3	0	4	60		1300	-5	22	22	145		
1900					1900	-5	9	10	126		1900	-1	3	3	129	
10	100				20	100	-1	0	3	39	30	100	-1	1	2	102
	700					700	0	7	7	150		700	0	-2	3	5
1300						1300	-1	0	2	41		1300	0	0	0	
1900						1900	0	2	2	136		1900	-1	0	2	37

KEY:

+cross-shore = offshore, cm/sec  
 -cross-shore = onshore, cm/sec  
 +longshore = south, cm/sec  
 -longshore = north, cm/sec  
 Speed = Resultant speed, cm/sec  
 Dir = Resultant direction, degrees true north

**Table 6**  
**Visually Observed Current Data**

Nov 1996												
Day	Pier End				Mid-Surf Zone				Beach			
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	4	-29	29	349	-14	-28	31	313	South	11	N	
2	-10	32	33	177	-13	32	35	182	North	27	S	
3	13	51	52	146	0	122	122	160	North	40	S	
4	6	20	21	70	0	0	0	0	North	9	N	
5	11	-36	37	357	-3	-11	12	323	South	18	N	
6	-6	20	21	250	-6	5	8	210	North	22	N	
7	2	-9	9	354	-14	-55	57	326	South	34	N	
8	-12	-41	42	323	2	-8	8	354	South	14	N	
9	15	25	30	70	-30	-61	68	313	South	40	N	
10	0	0	0	0	-18	-15	23	290	South	12	N	
11	8	17	19	133	14	28	31	133	North	14	S	
12	6	32	33	149	0	-21	21	340	North	24	S	
13	0	61	61	160	0	41	41	160	North	18	S	
14	-9	12	15	199	3	-6	7	11	South	9	N	
15	0	61	61	160	0	152	152	160	North	93	S	
16	-14	47	49	177	-19	-38	43	313	South	46	N	
17	14	28	31	133	-11	44	45	174	North	0		
18	0	0	0	0	19	-47	51	2	South	15	S	
19	5	11	12	133	0	-23	23	340	South	26	N	
20	6	30	31	149	-27	-38	47	305	South	14	S	
21	-6	24	25	174	-13	21	25	191	North	4	S	
22	0	122	122	160	0	152	152	160	North	94	S	
23	7	44	44	151	33	55	65	129	North	7	S	
24	11	-7	13	36	2	-10	10	351	South	0		
25	12	-29	31	2	3	-12	13	354	South	12	N	
26	15	-51	53	357	-18	-28	33	307	South	14	N	
27	5	51	51	154	0	87	87	160	North	67	S	
28	-2	47	47	163	-8	51	51	169	North	50	S	
29	5	24	25	149	-7	23	24	177	North	12	S	
30	-5	-18	19	323	9	-87	88	346	South	40	N	

KEY:

- +cross-shore = offshore, cm/sec
- cross-shore = onshore, cm/sec
- +longshore = south, cm/sec
- longshore = north, cm/sec
- Speed = Resultant speed, cm/sec
- Dir = Resultant direction, degrees true north

# Visual Observations

## 5

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Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

**Table 7**  
**Visual Observations**

Nov 1996						
Day	Time	Wave Approach Angle at Pier End deg from True N		Water Characteristics at Pier End		
		Primary	Secondary	Width of Surf Zone,m	Temp.,C	Density g/cc
1	0655	95		55	18.1	1.0229
2	0905	55		62	17.8	1.0222
3	0840	40		98	15.8	1.0199
4	0700	40		61	15.6	1.0196
5	0715	60		55	16.1	1.0204
6	0745	115		49	17.2	1.0215
7	0750	105		85	17.2	1.0221
8	0725	99		98	17.2	1.0221
9	0930	90		88	16.7	1.0232
10	0850	85	10	67	15.8	1.0234
11	0730	90	30	40	15.6	1.0233
12	0735	50		55	13.9	1.0236
13	0710	70		52	12.8	1.0206
14	0730	70		18	12.8	1.0202
15	0800	45		323	11.7	1.0200
16	0930	65	45	354	10.3	1.0182
17	0925	80		410	11.7	1.0197
18	0730	70		354	12.5	1.0211
19	0725	80		262	13.6	1.0221
20	0710	70	30	98	12.2	1.0216
21	0705	40		61	11.7	1.0216
22	0715	10		370	10.0	1.0192
23	1040	50		88	10.0	1.0192
24	0825	75		5	10.8	1.0211
25	0625	45		9	11.1	1.0215
26	0740	115		44	12.5	1.0232
27	0740	30		183	11.4	1.0244
28	0840	40		104	9.4	1.0221
29	0830	30		107	9.2	1.0197
30	0840	70		61	8.1	1.0191

# Water Levels

## 6

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Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level.

Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

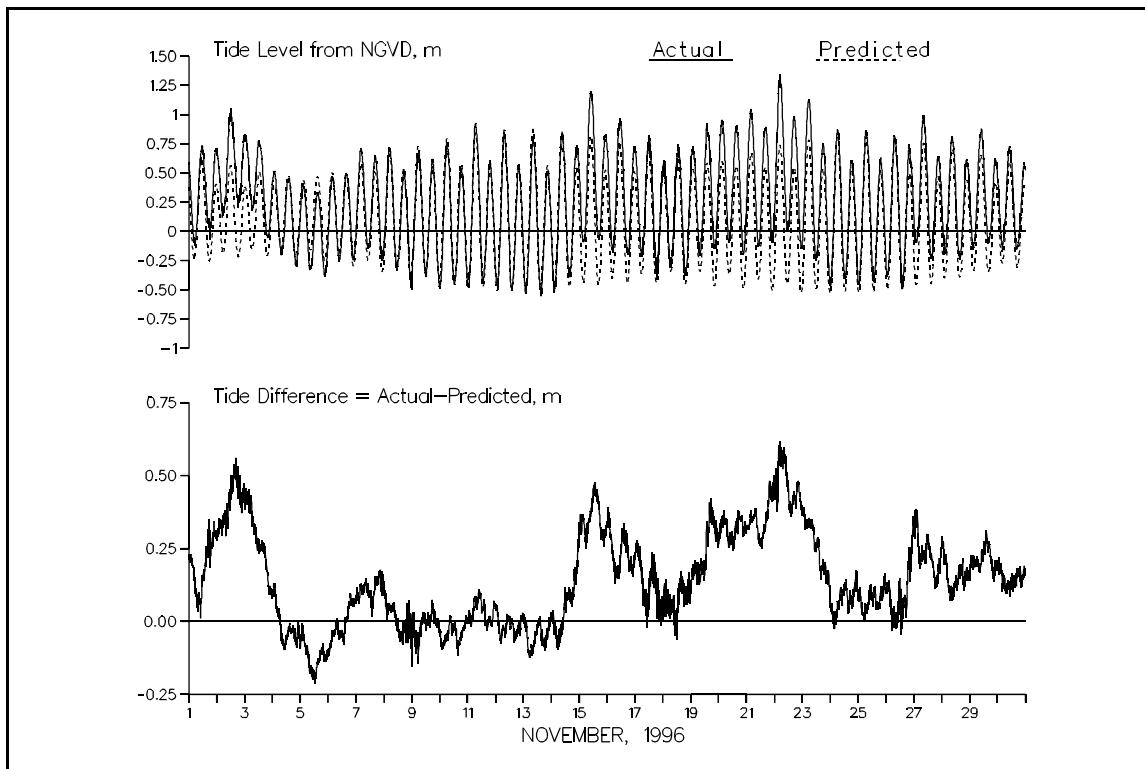


Figure 6. Water Level Variation

**Table 8**  
**Water Levels, m NGVD**

NOV 1996 Tide Levels																							
High				Low				Mean		Range		High				Low				Mean		Range	
Day	Time	m	Day	Time	m	m	m	Day	Time	m	Day	Time	m	m	Day	Time	m	m	Day	Time	m		
1	1130	0.74	1	0512	-0.12	0.31	0.86	16	1106	0.96	16	0448	-0.18	0.40	1.15								
1	2324	0.72	1	1748	-0.07	0.37	0.79	16	2336	0.73	16	1812	-0.20	0.27	0.93								
2	1212	1.05	2	0500	0.12	0.58	0.93	17	1224	0.82	17	0530	-0.22	0.29	1.04								
3	0042	0.83	2	1812	0.21	0.53	0.62	18	0048	0.61	17	1900	-0.42	0.13	1.03								
3	1206	0.78	3	0700	0.18	0.47	0.60	18	1312	0.74	18	0648	-0.31	0.20	1.05								
4	0106	0.52	3	2018	-0.06	0.21	0.58	19	0212	0.72	18	1924	-0.38	0.19	1.10								
4	1354	0.45	4	0748	-0.21	0.13	0.66	19	1348	0.92	19	0754	-0.21	0.36	1.13								
5	0206	0.41	4	2036	-0.31	0.06	0.72	20	0306	0.96	19	2024	-0.14	0.41	1.10								
5	1506	0.34	5	0812	-0.33	0.01	0.67	20	1536	0.90	20	0912	-0.10	0.41	1.00								
6	0348	0.47	5	2100	-0.39	0.05	0.86	21	0342	1.05	20	2118	-0.20	0.43	1.25								
6	1548	0.50	6	0936	-0.26	0.14	0.76	21	1624	0.90	21	1006	-0.13	0.40	1.03								
7	0418	0.71	6	2130	-0.25	0.23	0.96	22	0430	1.34	21	2212	-0.10	0.61	1.44								
7	1648	0.65	7	1036	-0.15	0.24	0.80	22	1712	0.99	22	1142	0.01	0.49	0.98								
8	0454	0.72	7	2254	-0.25	0.23	0.97	23	0524	1.13	22	2330	-0.15	0.49	1.28								
8	1700	0.54	8	1106	-0.34	0.09	0.87	23	1800	0.75	23	1148	-0.25	0.25	1.00								
9	0606	0.68	8	2354	-0.50	0.13	1.18	24	0618	0.88	24	0024	-0.47	0.20	1.34								
9	1718	0.62	9	1218	-0.39	0.10	1.01	24	1836	0.61	24	1248	-0.41	0.11	1.02								
10	0630	0.76	10	0012	-0.49	0.13	1.25	25	0654	0.87	25	0036	-0.45	0.21	1.32								
10	1836	0.54	10	1242	-0.46	0.03	1.00	25	1942	0.63	25	1330	-0.44	0.09	1.07								
11	0654	0.93	11	0036	-0.48	0.21	1.41	26	0706	0.82	26	0106	-0.39	0.21	1.21								
11	1912	0.61	11	1312	-0.44	0.08	1.04	26	1948	0.75	26	1342	-0.50	0.14	1.24								
12	0730	0.85	12	0136	-0.48	0.17	1.33	27	0836	1.00	27	0236	-0.10	0.41	1.09								
12	1942	0.57	12	1354	-0.51	0.03	1.08	27	2118	0.64	27	1506	-0.23	0.21	0.88								
13	0824	0.79	13	0212	-0.54	0.13	1.33	28	0836	0.81	28	0224	-0.20	0.30	1.01								
13	2048	0.52	13	1506	-0.56	0.01	1.08	28	2112	0.62	28	1518	-0.24	0.18	0.86								
14	0912	0.84	14	0236	-0.53	0.17	1.37	29	1006	0.88	29	0306	-0.16	0.36	1.03								
14	2200	0.74	14	1548	-0.39	0.19	1.13	29	2224	0.62	29	1606	-0.10	0.25	0.73								
15	1018	1.19	15	0348	-0.09	0.53	1.29	30	1006	0.73	30	0412	-0.17	0.29	0.90								
15	2248	0.83	15	1642	-0.07	0.38	0.90																

# Bathymetry

## 7

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A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using either a Trimble 4000 GPS or a Geodimeter 140-T self-tracking total station for positioning, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in October 1996 and the survey(s) in November 1996 on profile line 188, located 517 m south of the pier.

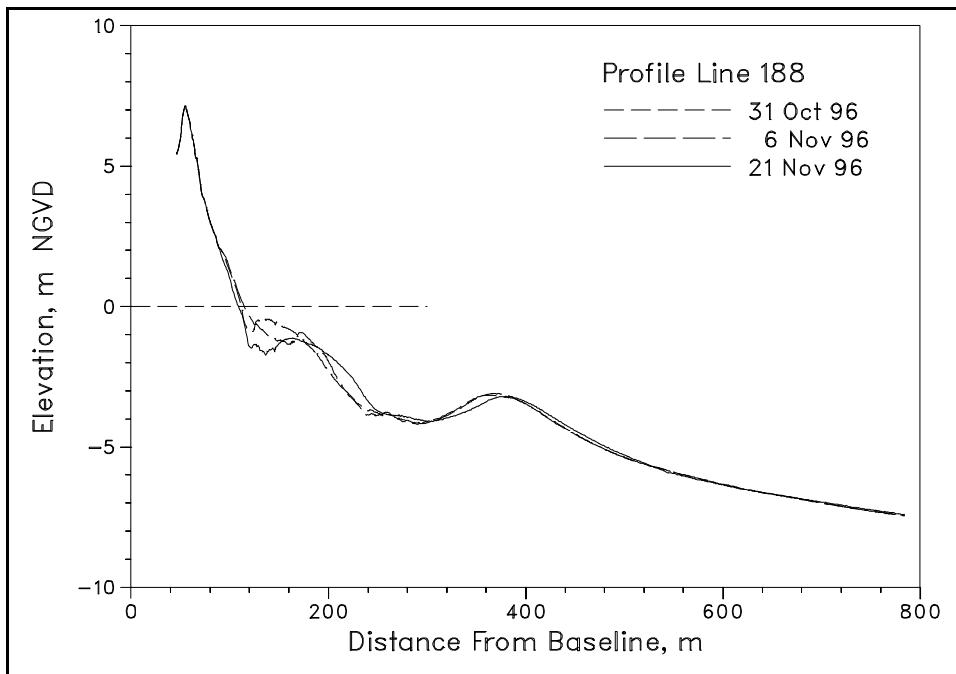


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1996. Cross-hatched areas indicate changes to the annual envelope which occurred in November.

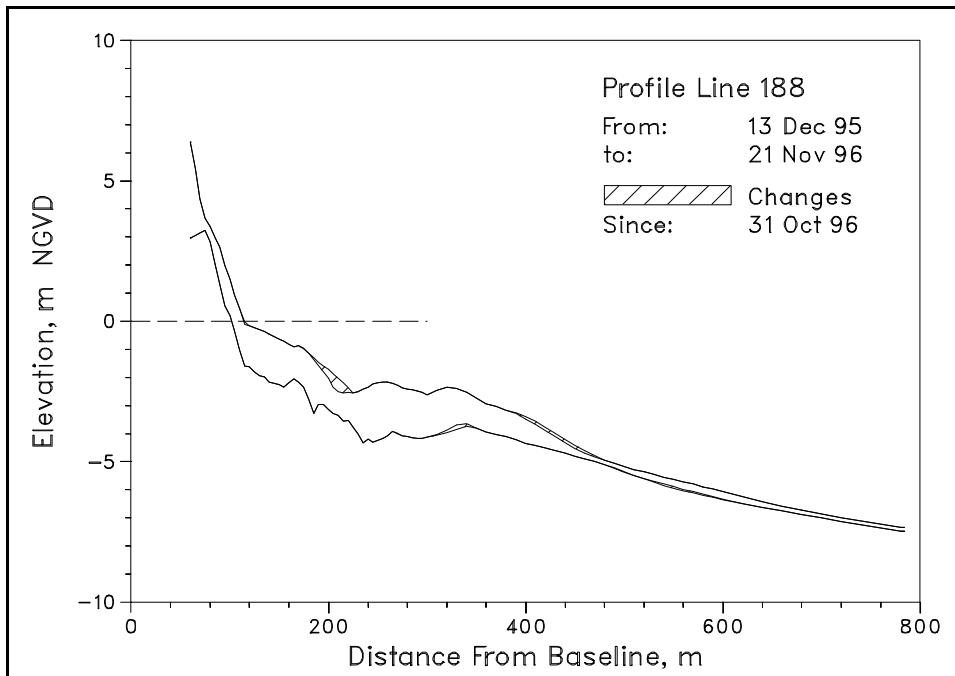
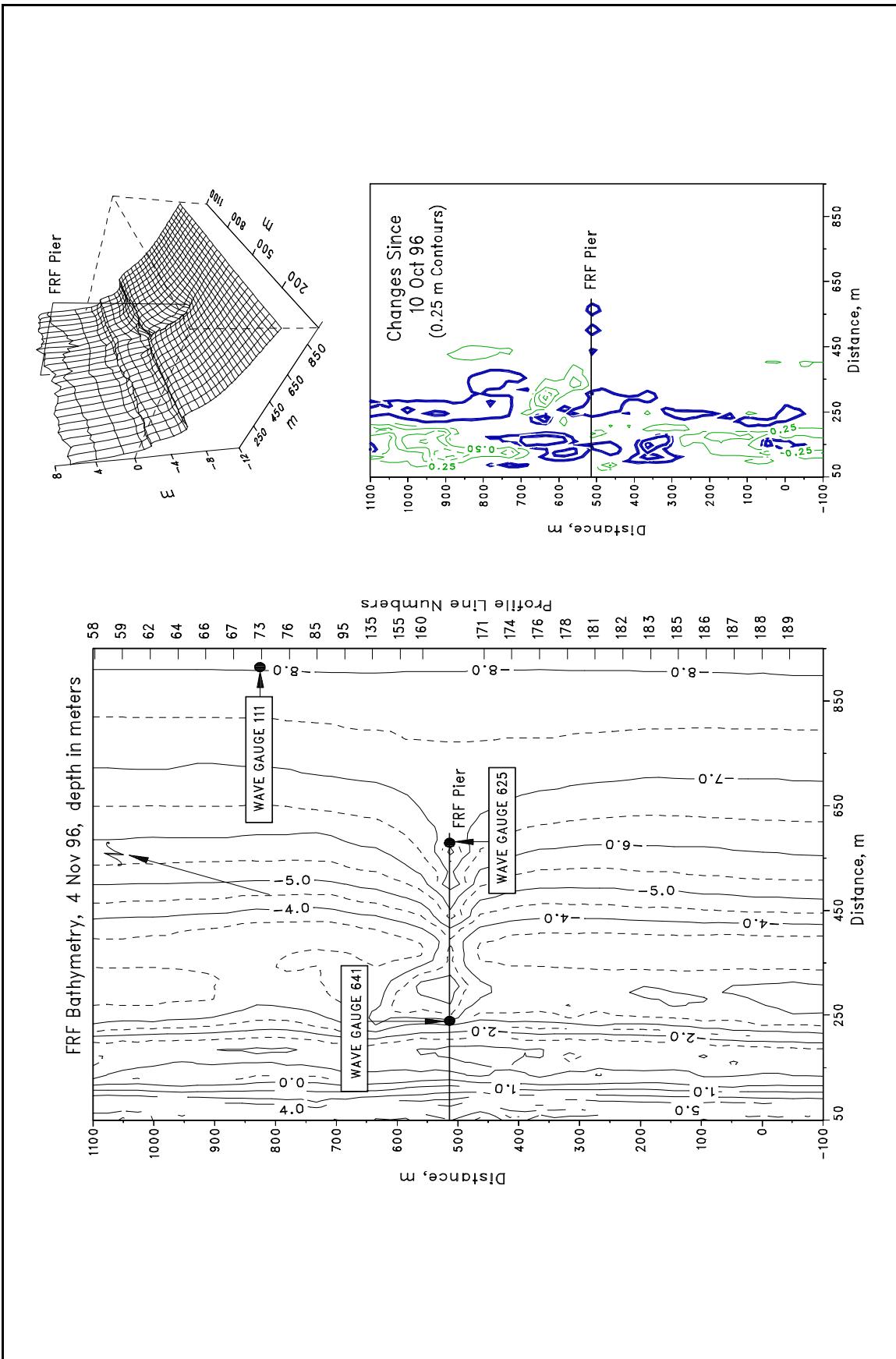


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 4 November. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.



# Special Events

## 8

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A. Storm Data Collection. The following list identifies times when the wave height  $H_{mo}$  at the seaward end of the pier exceeded 2 m.

	<u>Start</u>	<u>End</u>
15 Nov (0700)	18 Nov (1900)	
22 Nov (0134)	22 Nov (1216)	
26 Nov (2200)	26 Nov (2308)	

B. Storm Synopsis.

15-18 Nov Northeasterly winds associated with a slow moving Canadian high pressure system reached a maximum onshore velocity of 13 m/s at 0700 EST on 15 November. The maximum  $H_{mo}$ , at gauge 630, reached 3.2 m ( $T_p=18.0$  s) at 1634 EST on 17 November. There was 4 mm of precipitation.

22 Nov Northerly winds were funneled between a low pressure system offshore and a high pressure system to the west. Maximum wind speeds reached 20 m/s at 0734 EST. The maximum  $H_{mo}$ , at gauge 630, reached 3.1 m ( $T_p=7.7$  s) at 0700 EST. There was 24 mm of precipitation.

26 Nov A low pressure system, associated with a cold front, produced northerly winds of 18 m/s at 2234 EST. The maximum  $H_{mo}$ , at gauge 630, reached 2.7 m ( $T_p=6.3$  s) at 2308 EST. There was 2 mm of precipitation.